(12) UK Patent Application (19) GB (11) 2 080 437 A

(21) Application No 8022975
(22) Date of filing 14 Jul 1980
(43) Application published 3 Feb 1982
(51) INT CL³ F03B 13/12
(52) Domestic classification F1S 28BX
(56) Documents cited
F1S

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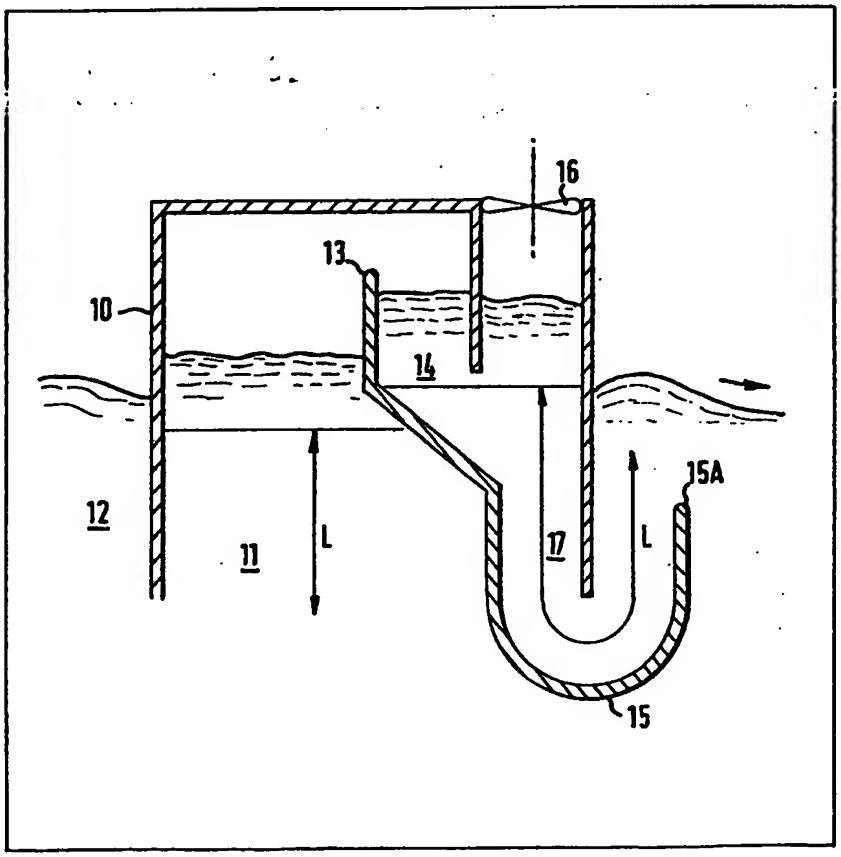
(54) Oscillating liquid column wave energy converter

(57) A converter comprises vertical sealed tube 10 open at its bottom in which upward and downward movement of a master column 11 of liquid takes place under periodic hydrostatic pressure variations. A second, U-shaped, tube 15 communicates with a turbine 16 and contains a second column of liquid 17 having a higher natural frequency of oscillation than the master column 11 and similar to that of the wave frequency. As the column 17 rises, it closes a port 14 to retain the master column 11 stationary, but the port 14 re-opens as column 17 falls. By this means the column 17 maintains the oscillations of master column 11 latched in phase with the wave motion. Extraction of its movement towards one end of its oscillations and the master column can be made much shorter than otherwise would be the case.



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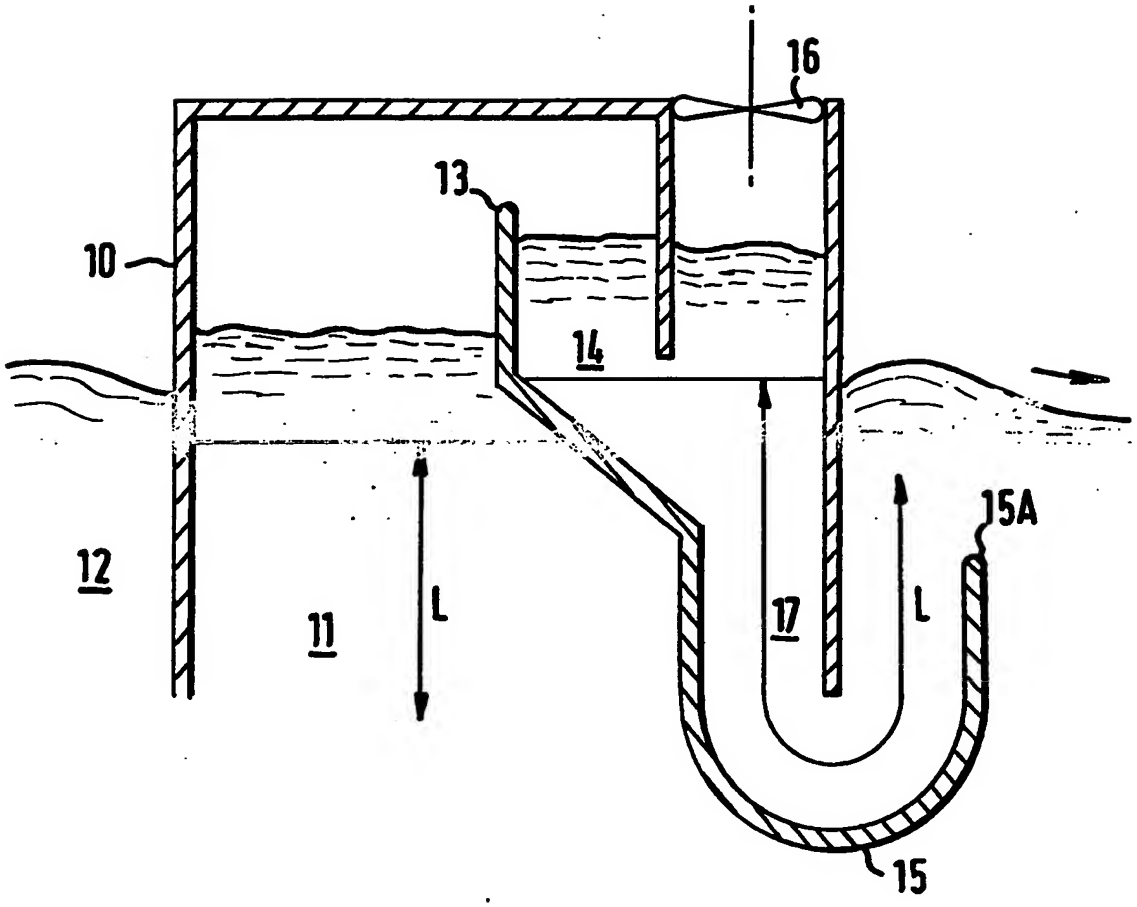

SPECIFICATION
Oscillating liquid columns

This invention relates to oscillating liquid columns particularly although not exclusively for use in wave energy convertors.

There have already been proposed various methods of arranging waves to act directly or indirectly on columns of water or other trapped liquid columns to cause movement of the liquid columns up and down. Movement of the liquid columns is used to drive a turbine or like device directly or via another liquid or gas moved by and in sympathy with the liquid column.

It is a requirement in any efficient oscillating liquid column arrangement to provide a liquid column having a natural frequency at least similar to the frequency of the waves that cause the oscillation of the liquid column. At present this means that massive and in particular very long columns of the order of say 20 metres are required. Although the overall space required can be reduced by using a U-shaped or other more convoluted-shaped columns, the provision of such lengths and shapes represents a serious handicap in particular to present day wave energy convertors.

It is an object of the present invention to provide an improved liquid column arrangement.

According to the invention, there is provided a liquid column arrangement for a wave energy convertor including a first tube containing a first liquid medium column and so connected to a body of water that upward and downward movement of the liquid medium column is produced by changes in hydrostatic pressure due to wave motion in the water, said first liquid column having a natural frequency substantially greater than the frequency of the wave motion, and a second tube in communication with the first tube and containing a second liquid medium column likewise acted upon by the wave motion and having a natural frequency at least substantially equal to the wave motion, the arrangement being such that movement of the second liquid column is caused to periodically inhibit movement of the first liquid column towards at least one end of its oscillations so as to maintain oscillations of said first liquid column substantially in phase with the wave motion.

A wave energy convertor having a liquid column arrangement according to the invention will now be described by way of example, with reference to the accompanying drawing which shows schematically part of a liquid column arrangement for use in the wave energy convertor.

In the drawing, a vertical sealed tube 10 containing a master liquid column 11 extends about 5 metres above the surface of a body of water 12 from a depth of approximately 10 metres below the surface. The master column has a natural frequency of about 0.2 cycles per second. The tube 10 is open at the bottom (not shown) so that the master column 11 moves up and down under periodic hydrostatic pressure variations caused by waves on the surface of the body of water 12.

There is air above the surface of the master column 11 and a ledge 13 over which the air can pass into a port 14 extending into a second U-shaped tube 15. The tube 15 extends upwards to a turbine 16 at one end and its other end 15A is positioned below the surface of the water 12. The effective length of the tube 15, is such that a second column of water 17 in the tube 15 has a natural frequency of oscillation similar to that of the water motion, about 0.1 cycles per second and higher than the frequency of the master column 11.

In use, the [illegible] of both the master column 11 and second column 17. When the second column 17 rises towards the turbine 16 it closes the port 14 to inhibit further upward movement of the master column 11. The column 17 continues to rise and as long as the port 14 is closed the master column tends to be retained stationary. The column 17 then falls in sympathy with the wave motion and the second column falls when the port 14 opens. The master column 11 moves downwards under the hydrostatic forces then being applied by the wave motion.

The sequence of column movements is repeated in periodic fashion with the result that the oscillations of the master column 11 are maintained substantially in phase with the wave motion, due to the opening and closing of port 14. By this arrangement the master column can be made much shorter than otherwise would be the case where its length would be required to extend about 20 metres below the surface of the water. Even if the master column were made U-shaped, considerable saving in length can be achieved by using said second tube and in such an arrangement a tube similar to tube 15 is preferably provided to inhibit movement at the other end of oscillation of the master column 11.

One significant further advantage in arrangements of this invention is that oscillations of the master column are controlled to maintain the master column in phase with the wave motion without using movable valves or independent wave motion sensing devices.

It will be noted in the described example, that the tube of the master column may be totally submerged beneath the surface of the water.

Whereas the description refers to wave energy convertors, a liquid column arrangement according to the invention can be used in other applications when an oscillating master column is maintained in phase with liquid column disturbing forces by a second column which operates to 'latch' the master column to the frequency of the disturbing forces.

CLAIMS

1. A liquid column arrangement for a wave energy convertor, including a first tube containing a first liquid medium column and so connected to a body of water that upward and downward

movement of the liquid medium column is produced by changes in hydrostatic pressure due to wave motion in the water, said first liquid column having a natural frequency substantially greater than the frequency of the wave motion, and a second tube in communication with the first tube and containing a second liquid medium column likewise acted upon by the wave motion and having a natural frequency at least substantially equal to the wave motion, the arrangement being such that movement of the second liquid column is used to periodically inhibit movement of the first liquid column towards at least one end of its oscillations so as to maintain oscillations of said first liquid column substantially in phase with the wave motion.

2. A liquid column arrangement according to Claim 1, in which there is a separate third tube containing a third liquid column, the arrangement being such that movements of the said second and third liquid columns are used periodically to inhibit movement of the first liquid column towards said one and the other end of its oscillations respectively.

3. A liquid column arrangement according to Claim 1 or 2, in which at least the first liquid column is provided with gas in communication with the liquid column and including a turbine arranged to be driven by movement of said gas.

4. A wave energy convertor having a liquid column arrangement substantially as herein described with reference to the drawing.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.